critical area (see Map, Fig. 1, p. 201). If such capture took place in Miocene times, it would appear to have been due to the hollow complementary to the ripple-crest which was at that time farther north-eastwards. Although the region was affected by widespread movements in Pliocene times, the crest may have tended to return south-westwards again as indicated first by the Crag outcrop and later (and farther south-westwards) by the rejuvenation due to uplift.

What was the impelling force driving the ripple so persistently north-eastwards, where did it originate, what are its effects outside this area, and what is the meaning of the rebound? These are theoretical considerations upon which it is better perhaps not to speculate at present, but which may open up fresh questions and lead to further investigation and accumulation of evidence.

Finally, it should be stated that the problem of attempting to prove the existence of an unstable axis was never embarked upon. The facts obtained in the course of working out other problems on each of the East Anglian deposits gradually fell into line.

III.—Tektite from British Borneo.

By Dr. F. P. Mueller, Basle (Switzerland).

It is well known that in various regions of Europe, Asia, and Australia dark pieces of glass are found which, in view of their peculiar shape and sculpturing, have attracted the attention of observers for a good many years. The name of *obsidianite* was given to these objects by R. H. Walcott. It expresses their resemblance in petrographic nature to obsidian.

Obsidianites are found in widely separated regions. It is evident from their physical and chemical properties that they belong to one petrographic class. However much they resemble one another there are points characterizing the specimens of each region. For this reason F. E. Suess has classified the obsidianites according to the main places of their occurrence, as *Moldavites*, *Billitonites*, *Australites*, and *Queenstownites*. In this view the origin of obsidianites is considered as a cosmic one, and excludes any comparison between them and obsidian; as an alternative the same author has chosen the name of *tektite* (τῆκτος, molten), which he thinks is less open to objection.

The origin of tektites has been dealt with in numerous publications. It is their occurrence upon or in later deposits remote from recent volcanoes and manufactories, and their shape and sculpturing, that have been considered as the result of their cosmic source. Many doubts have been expressed as to these points. The extreme discordance between the petrographic characters of meteorites and tektites, chemically belonging each to the opposite ends of the rock series, was supposed to prove the impossibility of a meteoric origin for the tektites. Yet it is evident from a study of the analyses that there is no agreement between the chemical composition of tektites and of any similar known terrestrial rocks. It will therefore be hardly possible to think of any other than a cosmic origin for them.

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The bibliography of tektites consists of numerous articles and monographs. Full lists are given in the following publications up to date of their appearance :—

1898. R. H. Walcott, Proc. Roy. Soc. Victoria, vol. xi, pp. 51–2.
1900. F. E. Suess, Jahrbuch K.K. geol. Reichsanstalt, vol. l, pp. 196–200.
1914. F. E. Suess, *Mitteilungen Geol. Ges. Wien*, vol. vii, pp. 54–6.

Attention must be drawn to the last of these three monographs. It gives full information on the chemical properties, and deals with all doubts that have been expressed on the origin of tektites. Further, it contains a description of a new kind of tektite, called Queenstownite.

It is the purpose of the present paper to describe a find of tektite from British Borneo, and specially to refer to those points which in view of the importance of this new occurrence are considered necessary.

The Tektites of the Sunda Archipelago.

The occurrences of tektites in the Archipelago, so far as known up to date, fall within an area that extends from the south-eastern corner of Borneo in a north-western direction to the southern portion of the Malay Peninsula, including the northernmost point of Java and the islands of Billiton and Great Natuna (Fig. 1).

The specimens from the Malay Archipelago are comparatively few in number, far fewer than the European and Australian tektites. Tropical vegetation and preponderance of sea within the above area might account for this.

Only in places where in consequence of mining operations the superficial deposits have been carefully examined, have a greater number of specimens been found, such as on Billiton Island and in the Malay Peninsula. Owing to the abundant occurrence at Billiton, the name of *Billitonite* has been assigned to all tektites from Malaysia.

It appears that the first Billitonite was found at Pleihari, in the south-east corner of Borneo, by S. Mueller, about the year 1836. A second specimen is known from the neighbourhood of one of the two Riam rivers, north of Pleihari. Two specimens are known from Mt. Muria, in Java, but only one appears to be an undoubted tektite. In 1879 P. van Dijk first described the Billiton occurrences, which were fully treated by R. D. M. Verbeek in 1897. In 1898 two specimens were recorded by P. G. Krause from Great Natuna. In 1909 a number of occurrences from the Federated Malay States was dealt with in the Geological Magazine by Mr. J. B. Scrivenor (p. 411).

The Tektites from British Borneo.

In February, 1913, the writer found four specimens of tektite in close proximity to Tutong Station, south-west of Brunei town. They were lying in a track, leading northward, and somewhat cut back into a small hill just behind the Chinese shops of the village. Apparently the stones were washed out of a white quartz sand, from a depth of one to two feet below the surface. This sand is part of a deposit that forms a well-marked terrace about 40 feet above sea-level along the coast of Brunei, especially near Yerudong, north-east of Tutong.

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The sand deposit certainly does not belong to the present epoch, but is at least of diluvial age. It is evident, therefore, that the tektites, like those of Billiton and of the Federated Malay States, geologically speaking are also of diluvial age.

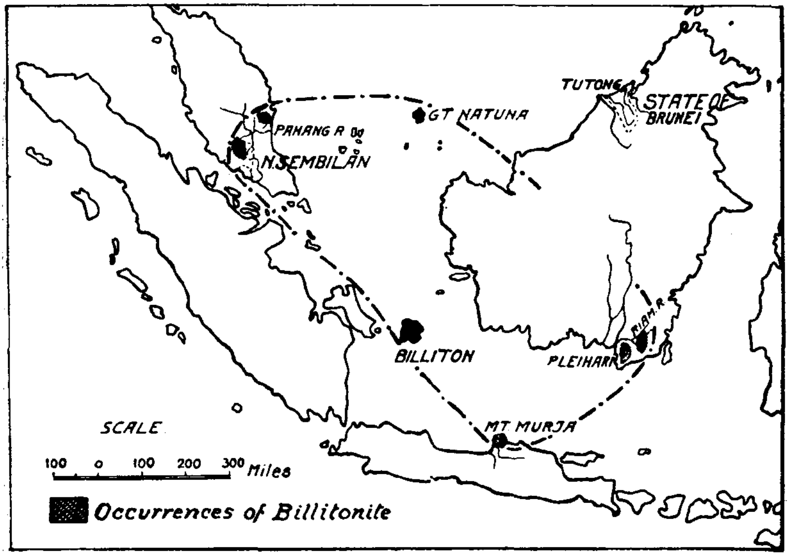

FIG. 1.—Map showing the area in which is included all known occurrences of Billitonite in the Malay Archipelago (dot and dash line).

The general characters of the Brunei specimens are shown in the following table (Table I):—

TABLE I.

No. of the Specimens	1	2	3	4
Size (mm.) . .	30/23/15	Diameter about 13	20/14/13	10/8/15
Weight (gr.) . .	11·72	5·37	5·87	0·5
Shape . . .	triangular	spherical	egg-shaped	triangular

The four specimens have the brilliant black lustre which is commonly characteristic of tektites. They are completely scored with very small marks, which makes their surface appear as if fine-grained. Closer examination shows the hemispherical moon-like hollows, often incompletely developed, which so commonly occur on Billitonites. Nos. 1 and 4 show a few deep, elongated pittings slightly wrinkled, rather smooth inside.

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Physical properties.—The specific gravity is G = 2·457. The hardness is H = 6. The colour is dark-green brown. The index of refraction, measured on two optic prisms prepared from No. 2, was found $n = 1{\cdot}5097$ (Na). All sections revealed without aid of the microscope a fluidal structure.

Microscopic examination proved the specimens to be an almost pure glass. A very few, small, scattered vesicles were noted, while by aid of the strongest enlargement only a few indeterminable mineral particles were observed. Comparing the physical properties with those of Billitonites it is evident that they are almost identical.

Chemical composition.—The following analysis of a Brunei tektite was made by Dr. Hinden in Basle. In the first column is shown the percentage of each oxide, and in the second is given the molecular proportion.

TABLE II.

SiO_2 . . .	70·90	118·17
Al_2O_3 . . .	13·50	13·24
Fe_2O_3 . . .	0·32	0·20
FeO . . .	5·47	7·60
CaO . . .	2·35	4·20
MgO . . .	2·45	6·12
Na_2O . . .	1·46	2·35
K_2O . . .	2·17	2·31
TiO_2 (estimated) .	1·00 (*ca.*)	1·25 (*ca.*)
MnO . . .	trace	—
	99·62	155·44

The accompanying diagram (Fig. 2), p. 210, has been drawn in order to compare the Brunei tektite with the Billitonites and the best corresponding Australites. It shows the molecular proportions of the principal oxides plotted as ordinates, those of the silica taken as abscissæ of five analyses of Australites (Nos. I, IV, V, VI, VIII), two of Billitonites (Nos. 9, 10), and one of the Brunei tektite (No. **a**). The diagram is a modification of the basic portion of F. E. Suess' Table iii, 1914. The roman numerals correspond with those by which H. S. Summers (Proc Roy. Soc. Victoria, vol. xxi, 1908) has marked the analyses of the Australites. The Arabic numerals are the numbers given in the same analyses as well as the analyses of the Billitonites by F. E. Suess, 1914, pp. 86–7 (see Table III, p. 211).

The examination of the diagram shows that the Australites and the Billitonites form two well-marked groups, their chemical variation being different in character. F. E. Suess (1914, p. 98) states as characteristic of the Billitonites the small percentage of alumina and the high percentage of alkalies. The rapid decrease of iron, magnesia, and lime is equally striking, while for the Australites these substances maintain an almost uniform position, diminishing very slightly only towards the acidic end of the series.

The Brunei tektite, as expressed by the diagram, though containing an almost equal quantity of silica as the Billitonites, shows little

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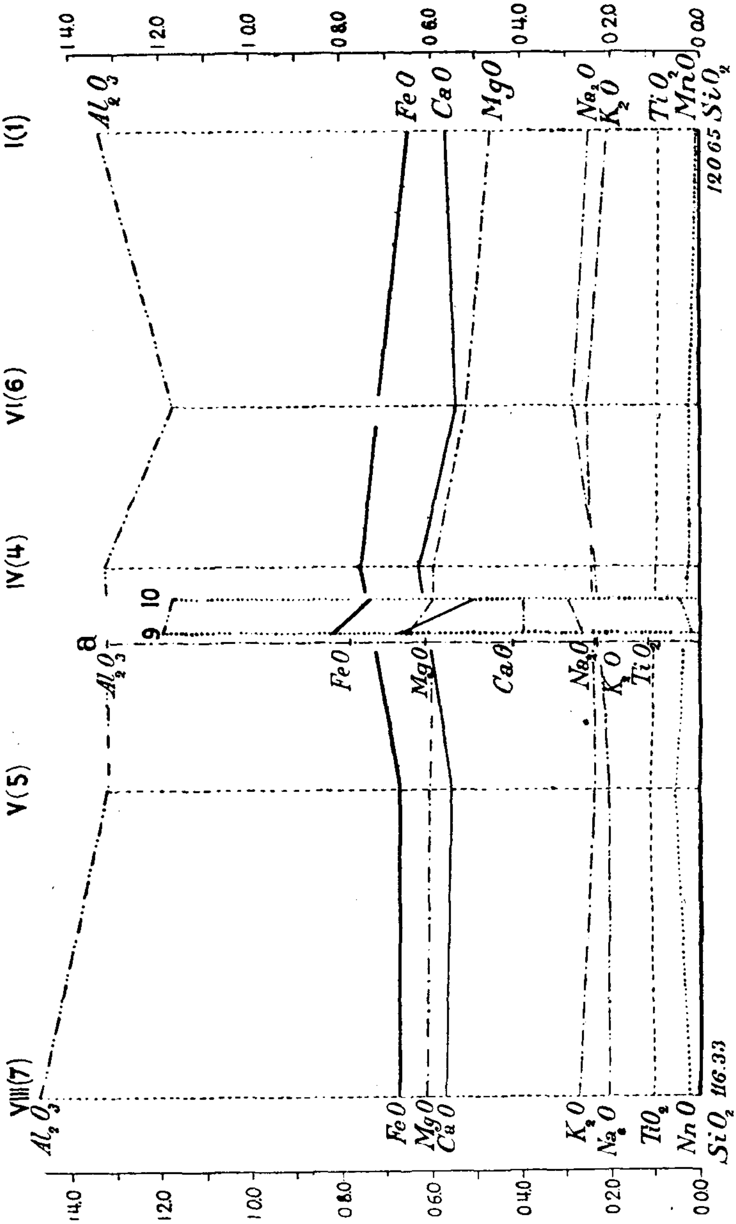

FIG. 2.—Diagram to show molecular variation in Australites (Roman numerals), Billitonites (Arabic numerals), and in the Brunei tektite (a).

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agreement with the above characteristics and those of the latter group. Its alumina is as high as that of the Australites. The alkalies are low, but equally correspond with the position of the alkalies of the Australites. There is also more agreement between the amount of iron and magnesia of the Australites and the Brunei tektite than between the latter and the Billitonites. Lime is irregular and comparatively low in position.

It is known that the quotient from the sum of iron and magnesia divided by the sum of the alkalies, as well as the ratios of lime, potash and soda are the evidences that distinguish the tektites from all terrestrial rocks. Besides this, moreover, they also characterize each group of the tektites, as is clearly shown in the following table (Table III). It is evident from the diagram and also from this table that the Brunei tektites do not correspond chemically with the group of the Billitonites, but that there is much resemblance between them and the Australites.

TABLE III.

Number of the Analyses.		$\frac{FeO + MgO}{Na_2O + K_2O}$	$CaO : Na_2O : K_2O$
Australites . . .	I	2·5	6 : 2 : 2
	IV	2·8	6 : 3 : 2
	V	2·9	5 : 2 : 2
	VI	2·7	5 : 2 : 3
	VIII	2·6	6 : 2 : 2
Billitonites . . .	9	1·9	5 : 3 : 4
	10	2·2	7 : 3 : 4
Brunei tektites . .	a	2·9	4 : 2 : 2

Conclusions.—The tektites from Brunei in British Borneo are, geologically speaking, most likely of diluvial age. Their shape and sculpturing show nothing peculiar. Their physical properties correspond with those of Billitonites. In their chemical composition there is much resemblance between them and the Australites.

IV.—STUDIES IN EDRIOASTEROIDEA, VII. MORPHOLOGY AND BIONOMICS OF THE EDRIOASTERIDAE.

By F. A. BATHER, M.A., D.Sc., F.R.S.

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THERE have now been described all the known members of the Edrioasteridae and the very similar genus *Steganoblastus*, as well as a genus apparently connected with the Agelacrinidae but presenting some remarkable features, namely *Pyrgocystis*. It is proposed in this and the following Study to deal particularly with

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